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U. S. DEPARTMENT OF AGRICULTURE - FOREST SERVICE
CALIFORNIA FOREST AND RANGE EXPERIMENT STATION
Division of Forest Insect Investigations

Lodgepole Needle Miner
Yosemite National Park, California
July, 1953
Appraisal Survey

By

R. C. Hall and B. E. Wickman

Berkeley, California
January 18, 1954

Lodgepole needle miner damage in young lodgepole pine stands. Tenaya Lake infestation, July, 1953. Snags are remnants of an older stand that succumbed to combined attacks of needle miner and mountain pine beetle 30 to 40 years ago.

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APPRAISAL SURVEY

Introduction

An appraisal survey of lodgepole pine stands infested with the lodgepole needle miner, Recurvaria milleri Busck, in the Tenaya Lake and Tuolumne Meadows recreation areas of Yosemite National Park was initiated on June 29, 1953. This survey was directed by R. C. Hall, assisted by G. L. Downing, C. J. Wray, B. E. Wickman, and field assistants - all of the Forest Insect Laboratory in Berkeley.

The objectives of the survey were (1) to ascertain and map the extent and the intensity of the needle miner infestation within an area of approximately 45,000 acres, and (2) to obtain an estimate of the relative numbers of needle miner larvae in the area scheduled for spraying and in a check area. Estimates of the larval population before spraying were necessary as a basis for comparison with post control data to determine the effectiveness of the spray.

There were three distinct phases to the survey: (1) intensive sampling of needle miner infested trees in the area to be sprayed and in a nearby check area; (2) aerial reconnaissance of the entire lodgepole pine type in the Park; and (3) ground reconnaissance of infested areas outside the control zone. A more detailed account of each phase will follow.

Historical Review

The activities of the lodgepole needle miner in Yosemite National Park were first reported to the Bureau of Entomology in 1903 by the Secretary of the Interior, who stated that large areas of lodgepole pine were being affected by a leaf-mining moth. In 1906, H. E. Burke investigated forest insect conditions in the Park, and reported that the death of the timber in the Tenaya Basin and adjacent areas was caused by the mountain pine beetle, Dendroctonus monticolae Hopk. In 1907, Prof. J. H. Comstock reported the presence of the needle miner in the Park.

Subsequent observations on the needle miner were made by J. M. Miller, who had charge of mountain pine beetle control operations in the Park in 1913 and 1914. The lodgepole needle miner was described by Busck (1) as a new species, Recurvaria milleri, on the basis of specimens collected by Miller. Patterson began a study of the life history of this insect in 1917 and later published the first comprehensive article on its habits (5).

In the mid thirties, Salman (6, 7, 8, 9) and Salman and Hensill (10, 11, 12) made some further observations on the life history of the lodgepole needle miner, but devoted most of their attention to the development of control measures with the insecticides then available. Tests indicated that petroleum sprays offered some promise, and in 1935 control of the needle miner on a pilot plant basis was attempted. The results, following application of a 4-percent tank-mixed emulsion, were generally unsatisfactory.

The search for more effective control measures, coupled with additional investigations on the life history and ecology of the needle miner, was continued by Yuill (14, 15, 16, 17) between 1937 and 1939. Yuill tested many different insecticides on a laboratory scale, but found few with sufficient promise to warrant testing in the field. A major obstacle to field testing was the limitations of spraying equipment then available; hence this line of study was dropped.

Development of Current Outbreak

The current outbreak first became evident in 1947, when heavy defoliation of lodgepole pine occurred along the Tuolumne Meadows road at the north end of Tenaya Lake, according to observations made by Emil Ernst and G. R. Struble. In 1949 an evident increase in the size and intensity of the outbreak was reported by these same observers. In August, 1949, field tests of DDT and benzene hexachloride applied by airplane were attempted, but because of hazardous flying conditions the tests were not completed. The two chemicals were highly effective when applied to small plots with ground equipment.

In the fall of 1952, a reconnaissance survey of Yosemite National Park indicated that the needle miner infestation in lodgepole pine covered an estimated gross area of 46,000 acres (13). The outbreak was considered especially serious because of the threat of widespread tree mortality, either as a direct result of defoliation, or through buildup of mountain pine beetle populations in the weakened trees. Plans were made, therefore, for more intensive surveys and a trial control operation in 1953, on the Tenaya Lake - Tuolumne Meadows area where recreational values are especially important.

Life History of the Insect

The lodgepole needle miner has a two-year life cycle. The adults appear during the period from July 1 to August 31 every other year on the odd-numbered years. Eggs are deposited under bud scales, between needles at their base and in old mined needles, from the end of July to early September, and the first instar larvae appear about 4 to 5 weeks after oviposition takes place. These larvae bore into needles and mine within the needles until cold weather prevents further activity. Feeding is resumed in the spring, and during the last part of August each larva migrates to a second needle where the second winter is spent. Early in the spring of the second year, a second migration by the larvae takes place when

they enter their third and last needles. The larvae pupate in this third set of needles from the first week of June to the first week of August, and moth emergence occurs as indicated above, completing the developmental cycle.

From reports by Salman and Yuill it appears that there are wide variations in the time of occurrence of different phases of the life cycle depending upon season and locality. These variations have an important bearing on timing of control work.

Status and Scope of Infestation

As stated earlier, the survey program was divided into three distinct phases: (1) intensive sampling of needle miner infested trees in the control area and check area; (2) aerial survey of the entire infested area in the Park; (3) reconnaissance survey of the most intensively infested areas not included in the control or check zones.

The first of these phases was carried out in the latter part of June by a four-man crew composed of Downing and Wray, assisted by David Todd and Allen Samuelson. Five lines of 10 trees each, selected at random, were sampled in each of the following: Tenaya Canyon and Dingley Creek in the control area and the upper Young Lake trail and Conness Basin of the check area (Fig. 1). Four terminal tips were cut from each tree at random at a height of 14 feet. These tips were labeled and taken to the Field Laboratory set up at Tenaya Lake Ranger Station, where population counts on ten needles of each tip were made. A random count of needles per tip showed 112 ± 12. The tips were then caged in 1-gallon ice cream cartons (Fig. 2).

From a preliminary study of population sampling it was determined that the 10-needle unit was the most efficient sample size (2). The samples were used to determine both population density and amount of defoliation. The results are tabulated below:

Area	Percent Defoliation	Mature Larvae and Pupae per tip		Number Adults per Tip	Number Parasites per Tip	Ratio Parasites/ Adults
		No. Living	% Dead			
Treated Tenaya-Tuolumne	70.8±1.6	18.4±0.9	41.4	17.9±2.1	1.66±0.28	0.09
Check Conness-Youngs	76.2±1.7	11.7±0.8	46.1	10.5±1.3	11.8±1.5	1.12

The second phase was carried out on July 1 by Wickman with the use of a chartered plane and pilot from Fresno. This phase consisted of sketch mapping the entire infested area in the Park by means of aerial observation. The infestation appeared heaviest in pure stands of lodgepole pine, which occur usually along creeks and canyon bottoms (Fig. 3). From the air it

appeared that the infestation areas of highest intensity were: Cathedral Basin, Dingley Creek, Conness Basin, Cold Canyon, McCabe Creek, Virginia Canyon, Spiller Creek, Matterhorn Canyon, and Jack Main Canyon (Fig. 4).

The last phase, that of ground checking the areas of heaviest defoliation, as determined by the aerial reconnaissance, was carried out during the month of July by Downing and Wickman. None of the areas could be reached by vehicle, and a pack outfit and a mobile camp were necessary to handle the ground checking. In this work needle counts were taken at random from the mid-crown of several trees in each area. From these counts an estimate of the degree of defoliation was arrived at by the use of a sequential sampling chart (Fig. 5). The following information was obtained:

Area	Degree of Defoliation	Appearance of Area
Conness Basin	Heavy	Very poor, extremely heavy defoliation
Dingley Creek	Heavy	Poor, heavy defoliation
Cathedral Basin	No count	" " "
Cold Canyon	Heavy	Very poor, very heavy defoliation
McCabe Creek	Heavy	Poor, heavy defoliation
Virginia Canyon	Heavy	Very poor, very heavy defoliation
Spiller Creek	Heavy	" " " " "
Matterhorn Canyon	No count	No check
Jack Main Canyon	No count	Poor, heavy defoliation

As a rule, mature trees were most heavily attacked (Fig. 6), although in areas of heavy infestation no preference was shown for age or size of tree. Limited samples taken at different levels in the crown indicated that the needle miner population is stratified, with the lightest populations in the lower crown. Moth emergence from rearings of 25 tip samples, collected at four different crown levels on five trees, was as follows: base of the crown 0.28 ± 0.09; 14-foot level 1.30 ± 0.26; mid-crown 3.32 ± 0.30; and tip 3.43 ± 0.40. All levels differed significantly between themselves except for the mid-crown and tip. This stratification conforms with visual appraisal of all men working on the project.

The Conness-Youngs area was selected as a check for the 11,100-acre area in Tenaya-Tuolumne watershed which was treated. As often happens, the treated and check areas are not strictly comparable. They differ significantly in the following respects: percent defoliation, number of mature larvae and pupae per tip, number of parasites per tip, and ratio of parasites to adults per tip (Table 1). The greatest difference between the two areas was in the ratio of parasites to adults. On the treated area the ratio was 0.09, compared to 1.12 for the check. Expressed in another way, there were over 12 times as many parasites per adult in the check area as in the one treated. In all population statistics of all stages of the needle miner these figures, numerically, were significantly higher on the treated area, whereas the percent of defoliation, the percent mortality of mature larvae and pupae, and ratio of parasites to adults were significantly greater on the check area. This fact will make an

evaluation of the effectiveness of control troublesome but not impossible. If the treatment is effective, the effects should be reflected by relative changes in 1954 populations of first stage larvae compared to the parent adult populations in the treated and check areas.

Discussion

The magnitude of the needle miner infestation, as revealed by these surveys, shows that it is the most extensive single insect infestation in the State at this time (Fig. 4). The infestation as a whole is very heavy, and in some cases trees that have been repeatedly defoliated during the current outbreak have already succumbed. Others may be expected to die if defoliation continues, or if the mountain pine beetle becomes epidemic in the needle miner weakened trees, as has happened in the past (Fig. 7). During the course of population sampling, one center of mountain pine beetle activity was found in Conness Basin; others that have escaped detection thus far may be developing. A separate appraisal of the Conness Basin infestation, to provide a basis for control planning, was made (3).

At this time it is very difficult to predict whether the level of the needle miner infestation is rising or falling. It is interesting to note that mortality among the larvae sampled was high, over 40 percent. Investigations by C. G. Thompson, Department of Biological Control, showed that a very high percentage of the larvae were infested with a virus disease. However, the presence of this disease did not seem to have an appreciable effect on moth emergence. This year's surveys provide a basis on which to make comparisons with data from subsequent surveys to determine changes in populations

Recommendations

(1) A post treatment appraisal survey of lodgepole needle miner populations in the sprayed and check areas should be made as soon as these areas become accessible to travel in the spring of 1954. On the basis of the survey findings the effectiveness of the 1953 control operations should be determined.

(2) Tests should be undertaken in the summer of 1954 to determine the possibilities of using DDT and other insecticides to control the larvae within the needles, or as they migrate from one needle to another.

(3) Further studies should be made on the ecology and seasonal history of the lodgepole needle miner as a basis for improving spraying schedules and techniques. Also needed are additional studies of natural control factors affecting this insect.

Berkeley, California
January 18, 1954

R. C. Hall, Entomologist

B. E. Wickman, Supervisory Control Aid

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UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

BERKELEY FOREST INSECT LABORATORY

LODGEPOLE PINE NEEDLEMINER INFESTATION

YOSEMITE NATIONAL PARK

1953

LEGEND

Boundary of Treated Area

Boundary of Check Area

SCALE

in 0 ½ 1 2 3 4 Miles

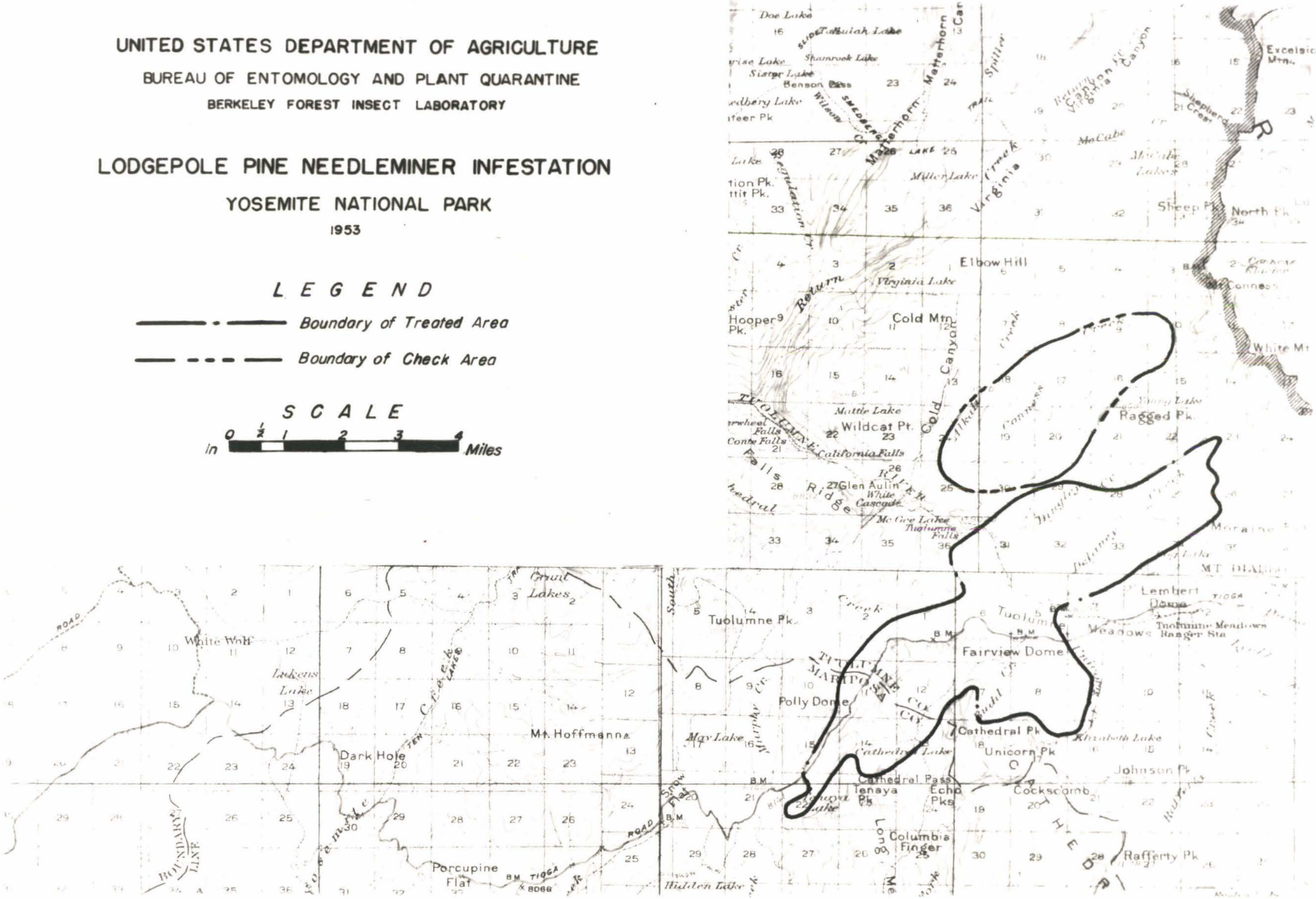
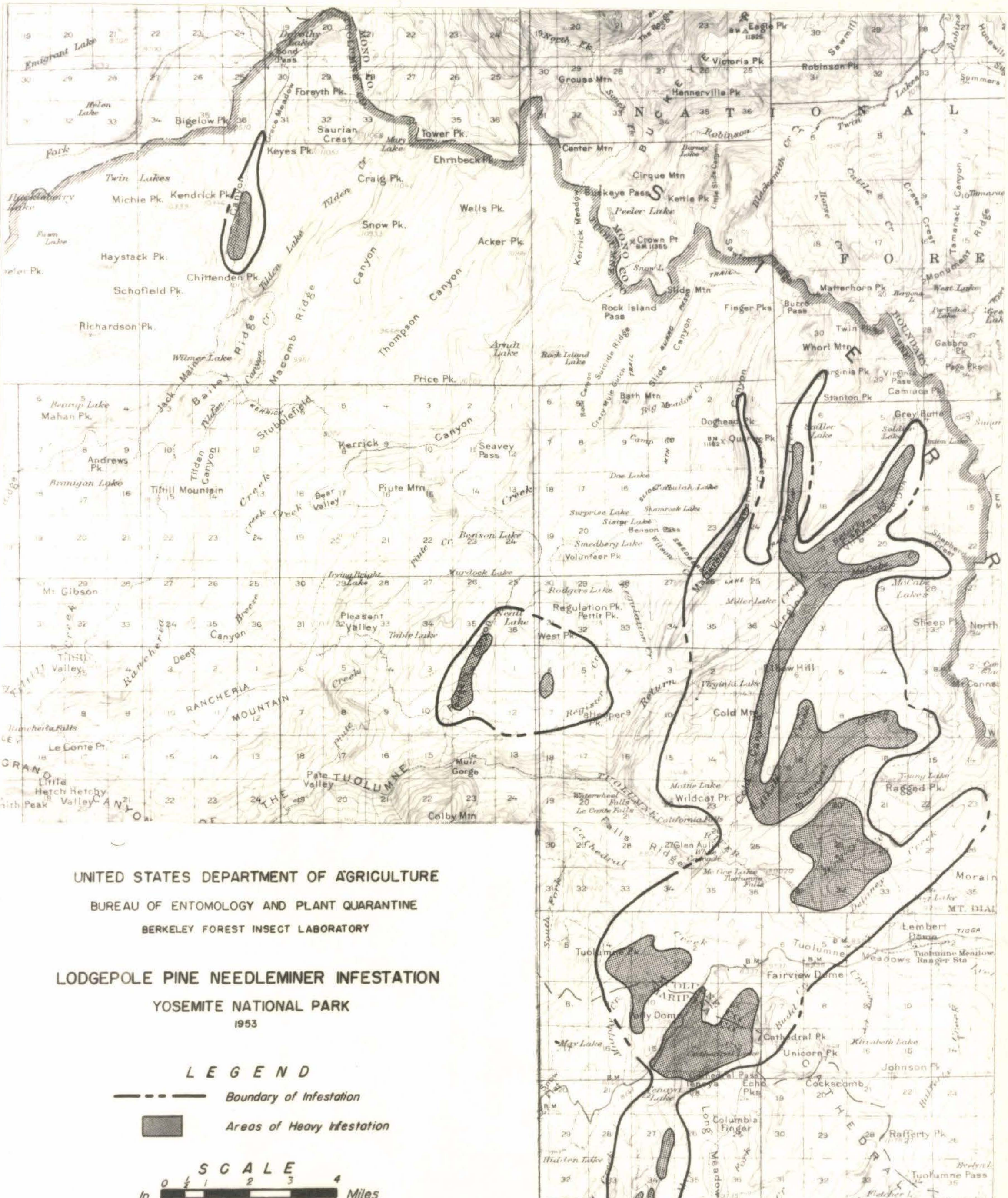


Figure 2. Cages set up for rearing out adult moths from twig samples. 1-gallon ice cream cartons with glass vials attached to top. Tenaya Lake Ranger Station, 1953.

Figure 3. Young lodgepole pine infested with needle miner in foreground, Hemlock stand in background. Tenaya Canyon, 1953.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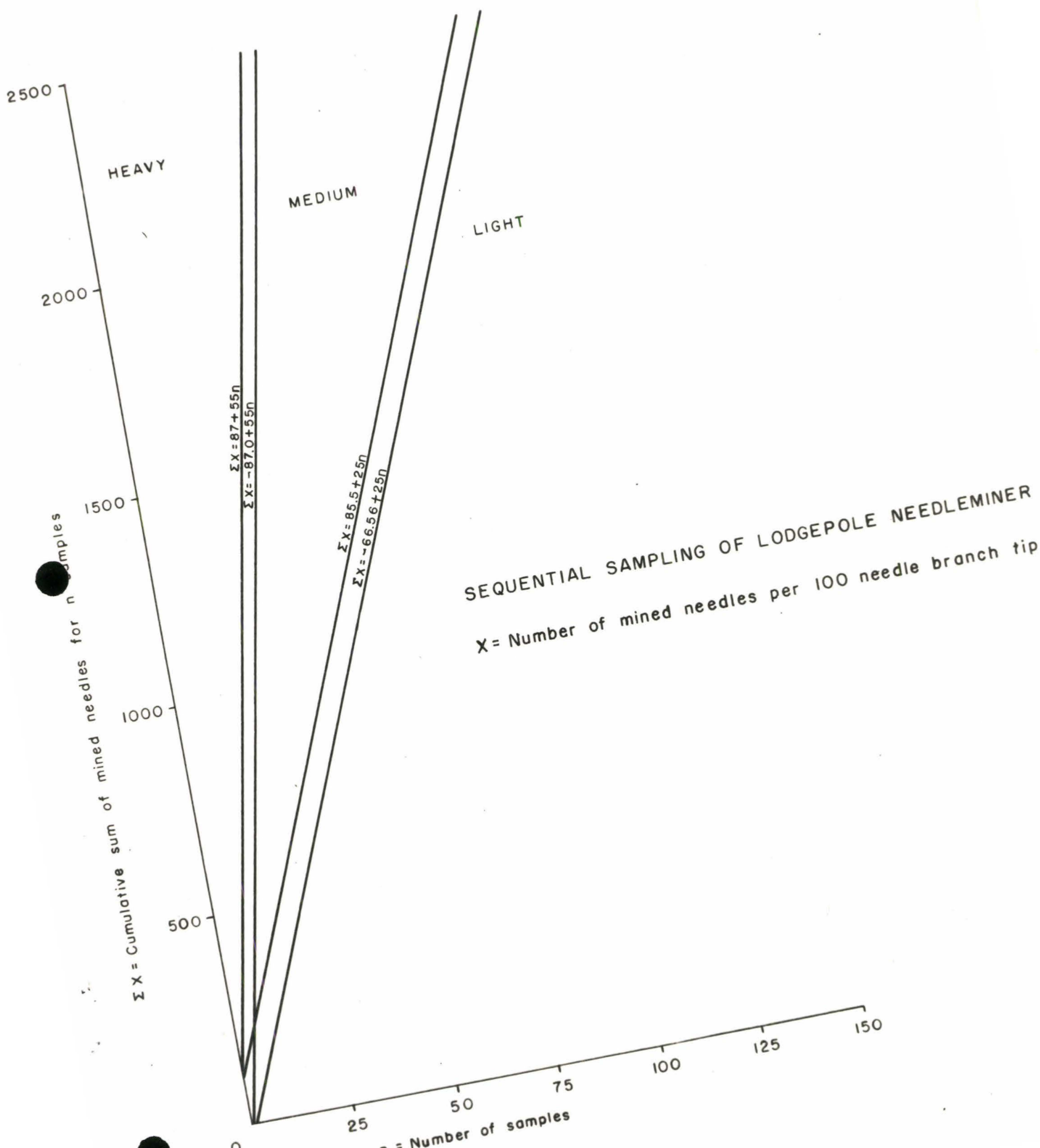
YOSEMITE NATIONAL PARK
1953
LEGEND
Boundary of Infestation
Areas of Heavy Infestation
SCALE
0 ½ 1 2 3 4
In Miles



SEQUENTIAL SAMPLING OF LODGEPOLE NEEDLEMINER

X = Number of mined needles per 100 needle branch tip

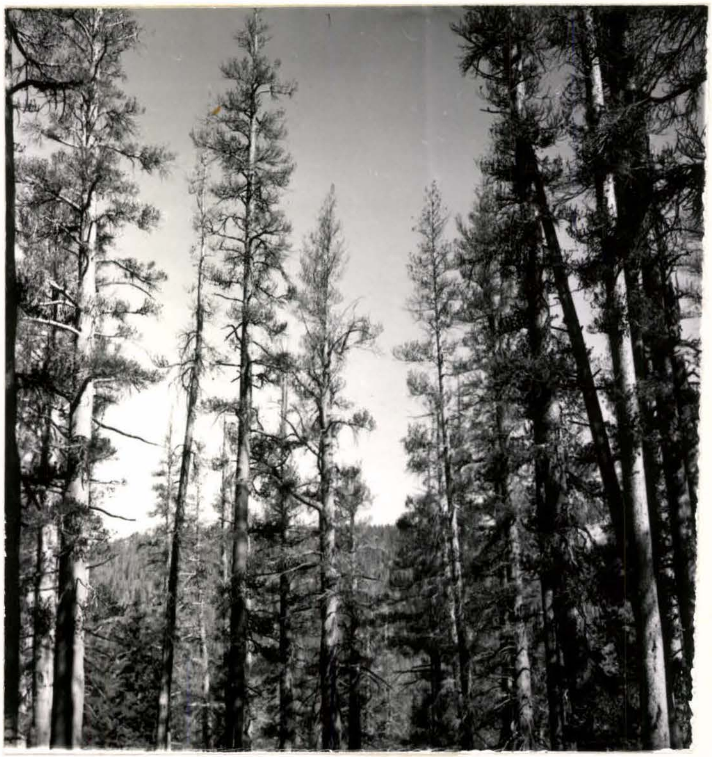


Figure 6. Mature lodgepole pine in Conness Basin, almost 100% defoliated by needle miner. Yosemite, 1953.

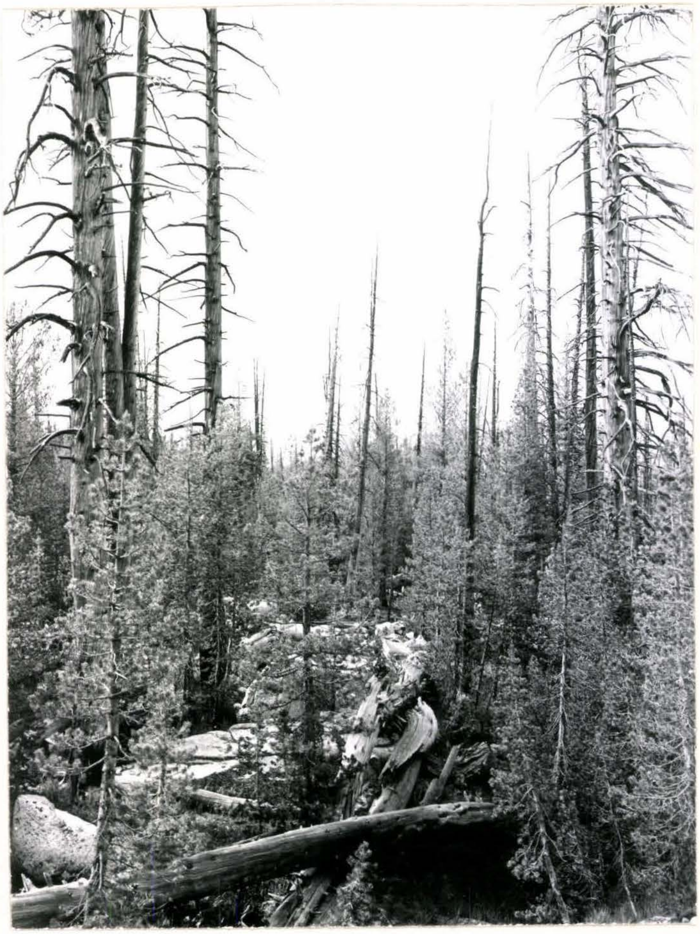


Figure 7. Lodgepole pine reproduction infested with needle miner in a "ghost forest" of lodgepole pine snags infested and killed 20 years previously by needle miner and mountain pine beetle. Tenaya Canyon, 1953.